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Possibilities and implications of using the ICF and other vocabulary standards in electronic health records

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Abstract

There is now widespread recognition of the powerful potential of electronic health record (EHR) systems to improve the healthcare delivery system. The benefits of EHRs grow even larger when the health data within their purview are seamlessly shared, aggregated, and processed across different providers, settings, and institutions. Yet, the plethora of idiosyncratic conventions for identifying the same clinical content in different information systems is a fundamental barrier to fully leveraging the potential of EHRs. Only by adopting vocabulary standards that provide the lingua franca across these local dialects can computers efficiently move, aggregate, and use health data for decision support, outcomes management, quality reporting, research, and many other purposes. In this regard, the ICF is an important standard for physiotherapists because it provides a framework and standard language for describing health and health-related states. However, physiotherapists and other healthcare professionals capture a wide range of data such as patient histories, clinical findings, tests and measurements, procedures, etc. for which other vocabulary standards such as LOINC and SNOMED CT are crucial for interoperable communication between different electronic systems. In this paper we describe how the ICF and other internationally accepted vocabulary standards could advance physiotherapy practice and research by enabling data sharing and reuse by EHRs. We highlight how these different vocabulary standards fit together within a comprehensive record system, and how EHRs can make use of them, with a particular focus on enhancing decision-making. By incorporating the ICF and other internationally accepted vocabulary standards into our clinical information systems, physiotherapists will be able to leverage the potent capabilities of EHRs and contribute our unique clinical perspective to other healthcare providers within the emerging electronic health information infrastructure.

Keywords

ICF; Logical Observation Identifiers Names and Codes; Systematized Nomenclature of Medicine; vocabulary; controlled

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Introduction

Against the backdrop of rising health costs and the inadequacies of a paper-based record system to support the many uses of health data, many health care systems around the world are launching large-scale e-Health (electronic health) initiatives (EHealth Suisse, 2009; European Commission: E-Health in Europe, 2009; Health Canada, Health Care System: eHealth, 2012; National EHealth Transition Authority, 2009; National Health Service, 2007; Office of the National Coordinator for Health Information Exchange, U.S. Department of Health and Human Services, 2011–2015; Swiss Confederation: Federal Office of Public Health, 2007). Although the use of electronic health record (EHR) systems by physiotherapists is not yet universal, there is considerable evidence that there are many potential benefits (Vreeman *et al*, 2006). Two common themes in the emerging e-Health environment are a) building connections between many independent systems to enable more fluid flow of patient information to those who need it, and b) the use of health information technology to support clinical decision-making. These two trends have highlighted the need for standardized terminology so that different EHRs systems can seamlessly share, aggregate, and process health data from many sources. As the electronic health infrastructure spreads, physiotherapists must evolve their documentation practices so they can contribute their unique clinical perspective in it, and leverage the features that can improve care outcomes.

EHRs can support decision-making through logic systems that generate reminders to clinicians as they interact with the system. Computerized reminders are suggestions about the care of an individual patient generated through introspection into the medical record. There is an astonishingly large body of evidence that computers can change clinician behavior. By providing key prompts they can help clinicians carry through on their good intentions of following recommended practice. The earliest studies demonstrating the potent impact of clinical decision support features were published in the 1970's (McDonald, 1976; McDonald, 1976), and there are now several large systematic reviews of the controlled trials that support this claim (Buntin *et al*, 2011; Chaudhry *et al*, 2006; Garg *et al*, 2005).

Computers can provide such recommendations only when they "understand" the contents of the health record. Often, the format of how clinical information is recorded makes that difficult. Unstructured "free text" narrative comprises much of traditional physiotherapy notes, and computers cannot easily interpret it without advanced techniques such as natural language processing (Nadkarni *et al*, 2011). There are trade-offs between documenting as free text compared to templated entry or recording as discrete observations and variables. Clinicians sometimes see systems that are optimized for structured data entry as unfamiliar, inefficient, and rigid (Ash *et al*, 2004).

Whether clinical information is entered as structured input or free text, an even more fundamental challenge to interoperable health data exchange is the plethora of local, idiosyncratic conventions for recording the same clinical measurements, findings, and phenomenon. Consider how a simple ambulation parameter might be identified in the health record: gait speed, walking velocity, walking rate, pace of ambulation, etc. Clinicians can easily tell that these have the same meaning, but computers cannot.

The only way to overcome this barrier is to adopt vocabulary standards, which provide a computable *lingua franca* across these disparate representations (McDonald, 1997; McDonald *et al*, 1998). Linking local data elements to codes from a standard vocabulary makes it possible to build bridges across the many islands of data from isolated systems. The greater the scope and depth of the information that is in the purview of the EHR, the greater the EHR's potential to deliver potent reminders that improve care (Kho *et al*, 2007). Since data about the patients we see is fragmented across many systems (Finnell *et al*, 2011), we need vocabulary standards to aggregate data in ways that EHRs can make use of them. Vocabulary standards provide a common language across these local dialects, enabling computers to move, aggregate, and use health data for decision support, outcomes management, quality reporting, research, and many other purposes.

Many physiotherapists are familiar with the World Health Organization's (WHO) International Classification of Diseases (ICD) for medical diagnoses. Another member of the WHO Family of International Classifications, the International Classification of Functioning, Disability, and Health (ICF), is gaining recognition as the preferred standard language for describing health and health-related states. However, there is scare evidence to suggest that it has been widely integrated into clinical documentation (Cawsey *et al*, 1997).

Furthermore, vocabulary standards are almost entirely absent from many other areas of physiotherapy documentation, such as recording discrete clinical findings, results of tests and measures, or identifying the specific interventions used (Vreeman, 2008). The field of biomedical informatics has developed several mature vocabulary standards whose scope includes these kinds of data (Cimino, 2011).

In this paper we describe how the ICF and other internationally accepted vocabulary standards could advance physiotherapy practice and research by enabling data sharing and reuse by EHRs. We highlight how these different vocabulary standards fit together within a comprehensive record system, and how EHRs can make use of them, with a particular focus on enhancing decision-making. By incorporating the ICF and other internationally accepted vocabulary standards into our clinical information systems, physiotherapists will be able to leverage the potent capabilities of EHRs and communicate their unique clinical perspective within the emerging electronic health information infrastructure.

Vocabulary Standards

Physiotherapists capture a wide range of clinical information, including family history information, environmental factors, examination findings, tests and measurements, and interventions. Today, there is no single comprehensive vocabulary standard today that covers this whole scope. In this paper we briefly introduce the ICF, LOINC® (McDonald *et al*, 2003), and SNOMED CT (IHTSDO. International Health Terminology Standards Development Organization, 2012) because they represent important internationally-adopted resources that enable reuse of clinical data by EHRs for many purposes (McDonald, 1997; McDonald *et al*, 1998; Cimino, 2011; Coonan, 2004). We stress that the primary role of these standards is to aid in computer processing. Clinicians need not see the actual identifiers (codes) and names from the vocabulary; these details could all be hidden inside the EHR itself while the clinician interacts with customary concept labels.

ICF

Many physiotherapists are familiar with the ICF (World Health Organization, 2012), a classification that provides both a framework and standard language, and the focus of this special issue of the journal. It includes components of health and some health-related components of wellbeing (such as education and labor). As a framework, ICF views an individual's functioning as an interaction between the health condition and contextual factors (i.e. environmental and personal factors). ICF domains are described from the perspective of the body, the individual, and society in two basic lists: (1) Body Functions and Structures; and (2) Activities and Participation. As a classification, ICF provides codes that systematically group health conditions through an ordinal scale of qualifiers. ICF codes are designed for use with qualifiers, and without them the codes have no inherent meaning.

LOINC

LOINC (Logical Observation Identifiers Names and Codes) is a universal code system for clinical observations (McDonald *et al*, 2003). It is developed by the Regenstrief Institute and made available for commercial and non-commercial use at no cost. LOINC provides codes and standardized names for tests, measurements, and other things you can observe about a patient or a specimen (e.g. a sample of blood drawn from a patient). For each concept, LOINC contains many other rich details, such as synonyms, units of measure, and carefully craftedclinically-relevant descriptions.

The current release, version 2.42 (December 2012), contains more than 71,000 such concepts for everything from a serum alpha 1 antitrypsin level to a zygomatic arch x-ray report. In addition to containing codes for simple measurements (body height, gait velocity, etc.), LOINC has evolved a comprehensive data model for representing the questions, answer lists, and different kinds of collections (instruments, forms, data sets, etc.) that contain them (Vreeman *et al*, 2010). LOINC contains codes for the assessments required by the Centers for Medicare and Medicaid Services (CMS) in the U.S., the American Physical Therapy Association's OPTIMAL instrument, and many more. It also contains a formal structure and codes for representing document titles (PT Progress Note, Discharge Summary, etc.) (Frazier *et al*, 2001; Hyun *et al*, 2009), radiology report names (Vreeman and McDonald 2005), and section headings (Social History, Objective, etc.).

LOINC has been widely adopted both within the U.S. and internationally, now with more than 220,000 users in 150 countries. Many countries have adopted LOINC as a national standard, and it is being used in large-scale health information exchanges around the world. The current version of LOINC has been translated into 10 different languages (Vreeman *et al*, 2012). Within the U.S. LOINC has been named as the standard for laboratory test names, other diagnostic measurements, functional status measurements, and other kinds of clinical "questions" (Health Information Technology Standards Committee, 2011).

SNOMED-CT

SNOMED CT (IHTSDO, 2012) is a comprehensive health terminology that provides a coded representation of meanings in health information. It is developed and distributed by the International Health Terminology Standards Development Organization (IHTSDO), a not-for-profit association that is owned and governed by its national Members. SNOMED CT is made available for use under license via the Member countries (currently there are nineteen Member countries of IHTSDO) or via special arrangements through the IHTSDO (fees may apply) (SNOMED CT Licensing. IHTSDO, 2012).

The scope of SNOMED CT covers a wide range of clinical information, including diseases, findings, procedures, microorganisms, pharmaceuticals, etc. SNOMED CT currently contains more than 300,000 active concepts with unique meanings that are organized into hierarchies with formal logic-based definitions. Within the terminology the coded concepts are represented with description logic, a language for representing knowledge. The description logic formalism enables computers to reason against the relationships between concepts stored in the terminology. For example, a computer could traverse the relationship that femur fracture "is a" fracture that "has body location" femur.

Because of its broad domain coverage, SNOMED CT provides a solid core terminology for the EHR. Within the U.S., SNOMED CT has been adopted as the vocabulary for coding entries in the patient's problem list, as well as the target vocabulary for the coded responses (answers) to clinical observations (questions) (Health Information Technology Standards Committee, 2011).

Relationship to Other Data Standards

In addition to vocabulary standards, EHRs need several other kinds of data standards to accomplish the goal of seamless and interoperable data sharing. A full discussion of health data standards is outside the scope of this manuscript, but as an example consider the seemingly straightforward task of sending an electronic clinical note from one provider to another in a computable manner. Even for this task, several different kinds of standards are needed.

Person identification standards ensure that individuals can be accurately identified when they have certain roles, e.g. patient, sending provider, receiving provider, etc. There are a variety of industry-wide technical standards and policies that can be employed to enhance data privacy and security (Cryptographic Toolkit. National Institute of Standards and Technology, 2012; Buckovich et al, 1999; Kwon and Johnson 2012). In addition, message standards like Health Level 7 (HL7) define a shared syntax that organizes clinical data into a structure for data exchange that can be understood by independent computer systems. The HL7 message standard (HL7 Application Protocol for Electronic Data Exchange in Healthcare Environments Version 2.7. 2011) is arguably the most widely implemented standard for healthcare in the world. Inside this standard are specifications for many kinds of clinical data exchanges, including patient administration, order entry, financial management, observation reporting (including laboratory tests, clinical measurements, etc.), master file management, scheduling, patient referrals, and more. Another widely used HL7 standard is the Clinical Document Architecture, which is a markup standard for specifying the structure and semantics of a clinical document, including text, images, and other multimedia content (Dolin *et al*, 2006). This standard is being rapidly adopted in many contexts, including the national EHR adoption efforts in the U.S.

Implications for Physiotherapy Practice

Documentation Templates as a Starting Point

Computers do their best processing on structured, coded data. Humans typically prefer narrative text because it is faster to process and can carry greater expressivity (Johnson *et al*, 2004; Cawsey *et al*, 1997). The optimal balance between data capture and data processing can be delicate (Rosenbloom *et al*, 2011). For physiotherapists whose record keeping practices are dominated by free flowing narrative, documentation templates might be a first step towards increasing structure that may help both humans and computers. Prior work has shown that templates can improve the consistency and comprehensiveness of documentation, but can also take more time (Rosenbloom *et al*, 2011; Marill *et al*, 1999; Laflamme *et al*, 2005). Templates are already used in many contexts; so augmenting locally developed ones with vocabulary standards might be a good first starting point.

An ICF-based template like the one proposed by Escorpizo *et al* (2010) could help orient patient management with the biopsychosocial model. The template might help clinicians consider how individual abilities can be improved both by intervention and modifying the environment. Organizing the patient record by the ICF model may also help characterize how interventions targeted at one dimension, e.g. functional activity performance, are associated with changes in another dimension like participation.

The structure of an ICF-based template provides information context that could facilitate ICF implementation research. For example, an EHR with ICF-based templates for documentation could be used to evaluate questions like (1) What are the most commonly used tests and measures for a particular ICF category? or (2) How well do the categories in the ICF Condition-specific Core Sets represent the attributes examined by physiotherapists?

Moving Towards Full Semantic Interoperability

Leveraging the full power of EHRs decision-making requires more structured data than templates alone. A few electronic systems now support capture of detailed narrative from clinicians, with tools like natural language processing to create partial structuring of narrative information for integration and reuse (Johnaon *et al*, 2008). We believe that such approaches may help accelerate the availability of codified clinical information within the EHR.

Getting complete, longitudinal information to follow patients will require their health data to flow fluidly among providers. Physiotherapists in this emerging ecosystem will need EHRs that understand data coming in from other providers and can send out clinical information in a way that other provider's systems can understand. This is, of course, the role of vocabulary standards.

Even with a basic understanding of ICF, LOINC, and SNOMED CT, it can be difficult to see how they should work together. Recognizing that few current systems support this level of semantic interoperability, here we present an example of how they can form a comprehensive representation of electronic data important to physiotherapists.

An Example of Functioning Data with ICF, LOINC, and SNOMED CT

Consider a physiotherapist working in an outpatient setting who is about to evaluate an elderly man whose main current complaint is hip pain with walking. Before the man arrives for his visit, the therapist's EHR receives key electronic documents from other providers, including discharge summaries, operative notes, and radiology reports. These predominantly contain loosely structured narrative text, but the document titles and section headers are identified with LOINC codes. The most recent laboratory test results come in as discrete data that are also identified by LOINC codes. This man's problem list also arrives electronically, is coded with SNOMED CT, and contains these entries:

Heart failure

Hypertensive disorder, systemic arterial

Atrial fibrillation

Tobacco dependence syndrome

Depressive disorder

Diabetes mellitus type 2

Osteoarthritis

Hip pain

This list contains some known impairments, but the therapist hypothesizes there are likely activity limitations, participation restrictions, and environmental and personal factors also contributing to his overall health. She will evaluate many aspects of the man's functioning, but let us consider just one specific aspect - walking short distances.

Not only does the ability to walk short distances relate to his chief complaint, but it is also an important contributor to his overall function and participation in many kinds of domestic and social activities. Many potentially important attributes of walking can be evaluated with myriad methods. For example, speed, distance, risk for falling, quality of joint movement, or basic properties like muscle strength, joint range of motion, etc.

Among other measures, our therapist decides to record his average walking speed because it is an important predictor of potential adverse events like hospitalization (Montero-Odasso *et al*, 2005). This measurement could be represented with the LOINC code:

41957-2	Walking speed	Vel	24H^mean	^Patient	Qn	Calculated

Similarly, a good predictor of functional exercise capacity and prognosis in people with heart failure is the distance walked in six minutes (Arslan *et al*, 2007), which could be represented with the LOINC code:

64098-7	Walk distance	Len	6M	^Patient	Qn

The therapist could assess risk for falling by administration of a patient-reported outcome instrument like the Tinetti Performance Oriented Mobility Assessment (Tinetti, 1986). Or, instead of administering a full instrument, perhaps she might just ask a simple question like “have you had two or more falls in the past year or any fall with injury in the past year?” Both widely-used questions like this and full outcomes assessment instruments Standardized assessments like this can be modeled well in LOINC, but there are many used in the field that are not yet in LOINC.

During the evaluation, the therapist records that the man has an antalgic gait, palpable hip joint crepitus, and leg length inequality. Each of these clinical findings could be identified by codes from SNOMED CT:

67141003	Antalgic gait (finding)
299310009	Hip joint crepitus palpable (finding)
45939007	Leg length inequality (finding)

(If needed, the exact amount of the leg length inequality could be represented by a LOINC code for that measurement).

These discrete observations and measurements inform the therapist’s assignment of the ICF code for this domain (d4500 Walking short distances). The therapist synthesizes these results into an overall impression by assigning the generic performance in the current environment ICF qualifier:

xxx.0 NO problem

xxx.1 MILD problem

xxx.2 MODERATE problem

xxx.3 SEVERE problem

xxx.4 COMPLETE problem

xxx.8 not specified

xxx.9 not applicable

She chooses “moderate problem”, which translates into code d4500.2 “moderate difficulty with walking short distances with the use of assistive devices that are available to the person in his or her current environment”.

With the clinical information stored in this way, we have a powerful set of coded data that is readily understandable to independent computers systems.

How ICF-powered EHRs Could Enhance Physiotherapy Practice

Computer-interpretable clinical information can become the grist for many tools and processes with the potential to enhance physiotherapy practice. Here we provide a few hypothetical examples based on modest extensions to previously published work about a locally-developed system called Child Health Improvement through Computer Automation (CHICA) used in a busy pediatric medical setting (Biondich *et al*, 2003; Anand *et al*, 2004; Downs *et al*, 2006; Downs *et al*, 2008; Carroll *et al*, 2011). There are certainly many other advanced EHRs, including both commercially available and even no-cost, open source systems like OpenMRS (Mamlin *et al*, 2006; Tierney *et al*, 2010). We describe CHICA simply as an exemplar system that is based on best practices in informatics.

CHICA is an advanced EHR tailored for pediatric health. CHICA captures structured data directly from clinicians and families and delivers computer-generated, patient-specific reminders. Surprisingly, CHICA's interface for families and clinicians is not a computer, but rather computer-interpretable, bi-lingual paper forms. These forms collect handwritten responses, are scanned, and then read by optical character and mark recognition software. The first form is a "prescreening" form to collect data from clinic staff and parents before the patient is seen. The questionnaire is created when the patient arrives and contains places for nurses to record information like vital signs as well as questions for the parents. The system selects the 20 highest priority questions for that particular visit, drawn from a large database of potential questions and informed by existing health record data. After scanning, the system merges this data with the existing health record information to generate a provider encounter form. The encounter form can contain up to six computer-generated reminders for the clinician. CHICA can also print "just in time" handouts for the provider or the patient. In several studies, CHICA has been shown to enhance screening and guideline-based care (Downs *et al*, 2008; Carroll *et al*, 2011). Further, clinicians have spontaneously offered anecdotes of how grateful they were for key alerts it provided, like the presence of guns within homes or abusive family situations.

It is easy to imagine how a system like CHICA could be enhanced with the ICF (or the ICF for children and youths, ICF-CY (Lollar *et al*, 2005)). Presently, CHICA employs a global prioritization scheme for choosing the most important questions for the current visit. Prioritization schemes could incorporate tailoring to condition-specific components based ICF core sets. In the pediatric context, many important health risks are contextual factors, which can be readily captured by questions like "does [child]'s home have a pool?" or "are all household products (medicines, cleaning supplies, other chemicals) being securely placed out of [child]'s reach?" (Carroll *et al*, 2011) Similarly, key aspects of neuromotor development could be screened by asking parents about the child's ability to perform certain activities (e.g. getting into a sitting position) relevant for their stage of development. Likewise, the system could be modified to automatically select items for the provider to assess based on condition-specific ICF core sets that took into account the known and reported patient history stored in the EHR.

ICF-based clinical practice guidelines such as those currently being developed by Sections of the American Physical Therapy Association (Godges and Irrgang 2008; Childs *et al*, 2008) could provide the essential substrate for generating physiotherapy-specific reminders. In settings where the ICF qualifiers are being routinely assigned, the EHR system could automatically generate reports such as the ICF Evaluation Display described by Rauch *et al* (2010) or calculate overall level of functioning scores such as those described by Cieza *et al* (2009). Having the system produce these ICF-enhanced tools at the time of a clinical encounter could assist the clinical decision-making of physiotherapists.

We present these few examples of possibilities for ICF-powered EHRs with the hope of sparking many other ideas that will be developed and tested for their effectiveness in real-world systems. Like all informatics interventions, their efficacy should be evaluated with controlled trials (Vreeman, 2004).

Future Directions

Physiotherapists are starting to gain experience with translating the information obtained by tests and measures into ICF qualifiers. Some authors have started describing the relationship between the ICF and standardized assessments such as the SF-12 (Mayo *et al*, 2004), outcomes measures for inflammatory bowel disease (Achleitner *et al*, 2012), and others. Such work is crucial, particularly in areas where there are a plethora of measures being used in the field (Hoang-Kim *et al*, 2013). Further, new assessment tools are being developed that have explicit linkages back to the ICF framework (Balestrieri *et al*, 2012).

Additional work is needed to define the relationships between assessment instruments, ICF, and other vocabulary standards in a computer-interpretable way. Portions of the ICF have now been incorporated into the National Library of Medicine's Unified Medical Language System, which enables cross-references to other terminologies such aslike LOINC and SNOMED CT (National Library of Medicine Unified Medical Language System, 2009). There is also newly launched effort between the WHO and IHTSDO to better align ICF and SNOMED CT (Jane Millar, personal communication). This project involves three progressive phases: 1) a gap analysis conducted with a robust methodology, 2) addressing the detected alignment gaps between the two vocabularies, and 3) modeling the content in both vocabularies with aggregation logic that provides the linkage between them (IHTSDO, WHO and IHTSDO, 2012).

Conclusion

The ICF and other internationally accepted vocabulary standards can advance physiotherapy practice and research by enabling data sharing and reuse by EHRs. We have highlighted how these different vocabulary standards fit together within a comprehensive record system, and how EHRs can make use of them. By incorporating the ICF and other internationally accepted vocabulary standards into our clinical information systems, physiotherapists will be able to leverage the potent capabilities of EHRs and contribute our unique clinical perspective to other healthcare providers within the emerging electronic health information infrastructure.

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